Sept. 29, 1953 E. C. GOODWIN 2,653,853

SPEEDGRAPH RECORDER

Filed Nov. 26, 1949 2 Sheets-Sheet 1

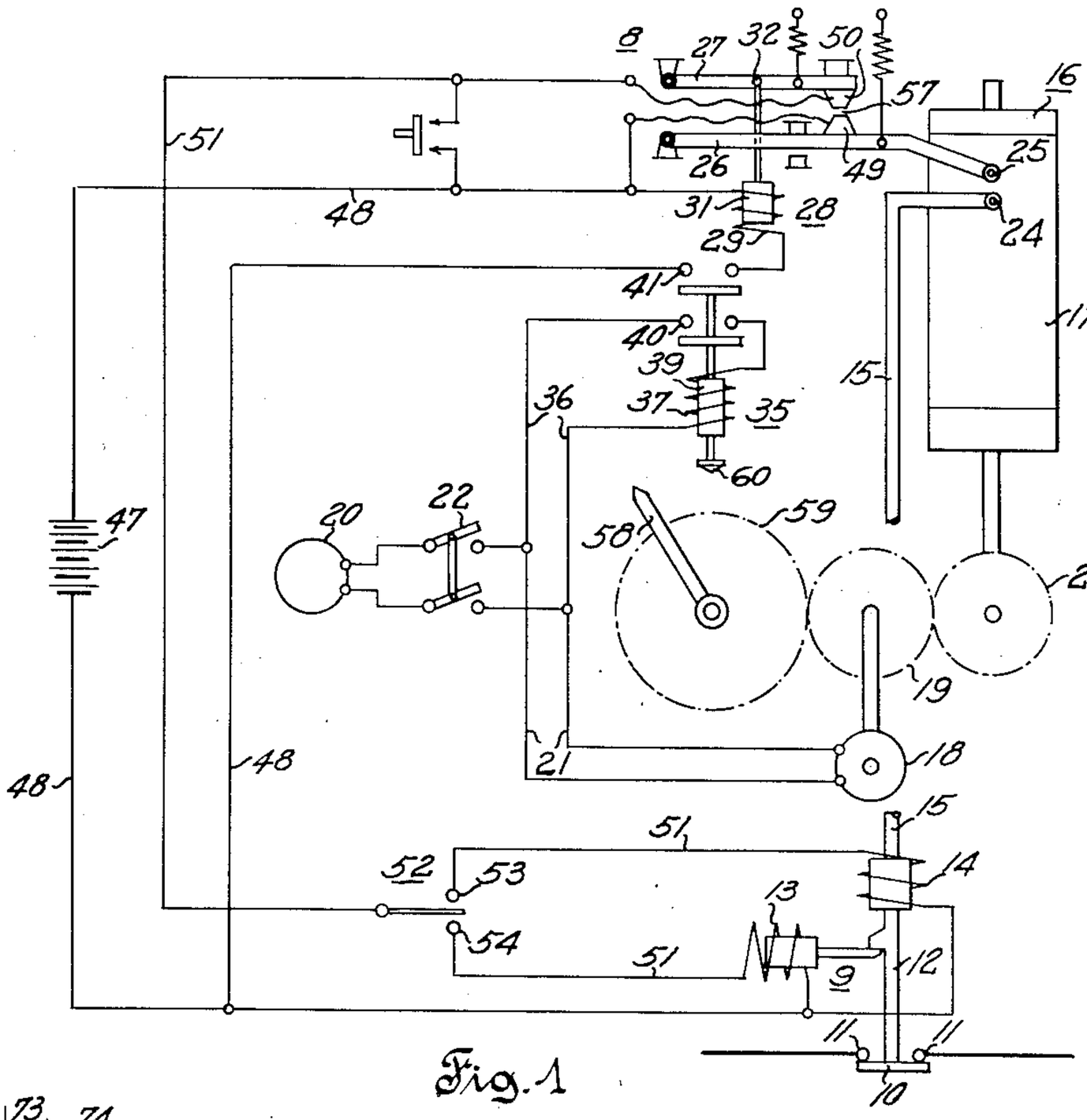

Fig. 1

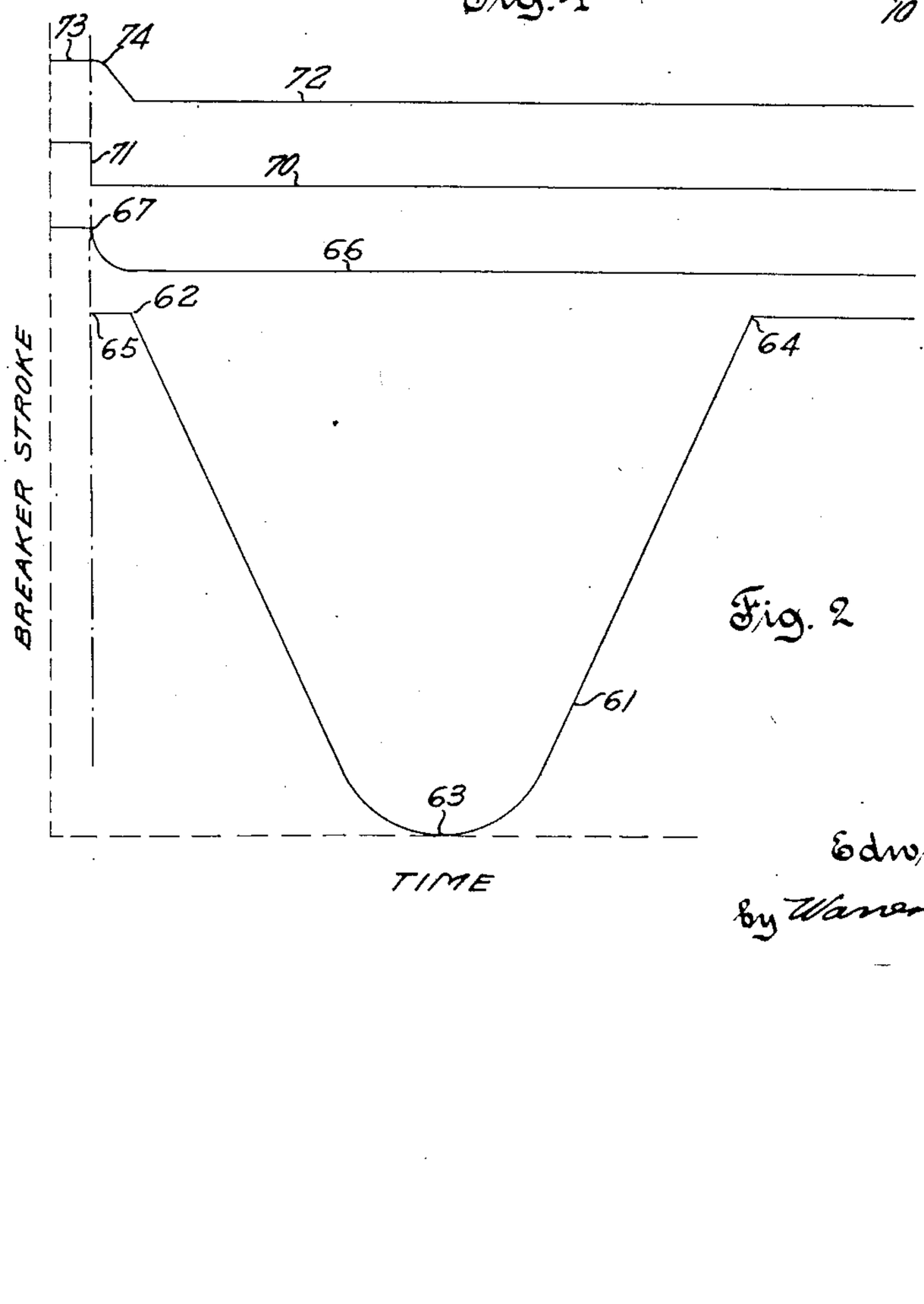

Fig. 2

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2 Sheets-Sheet 2

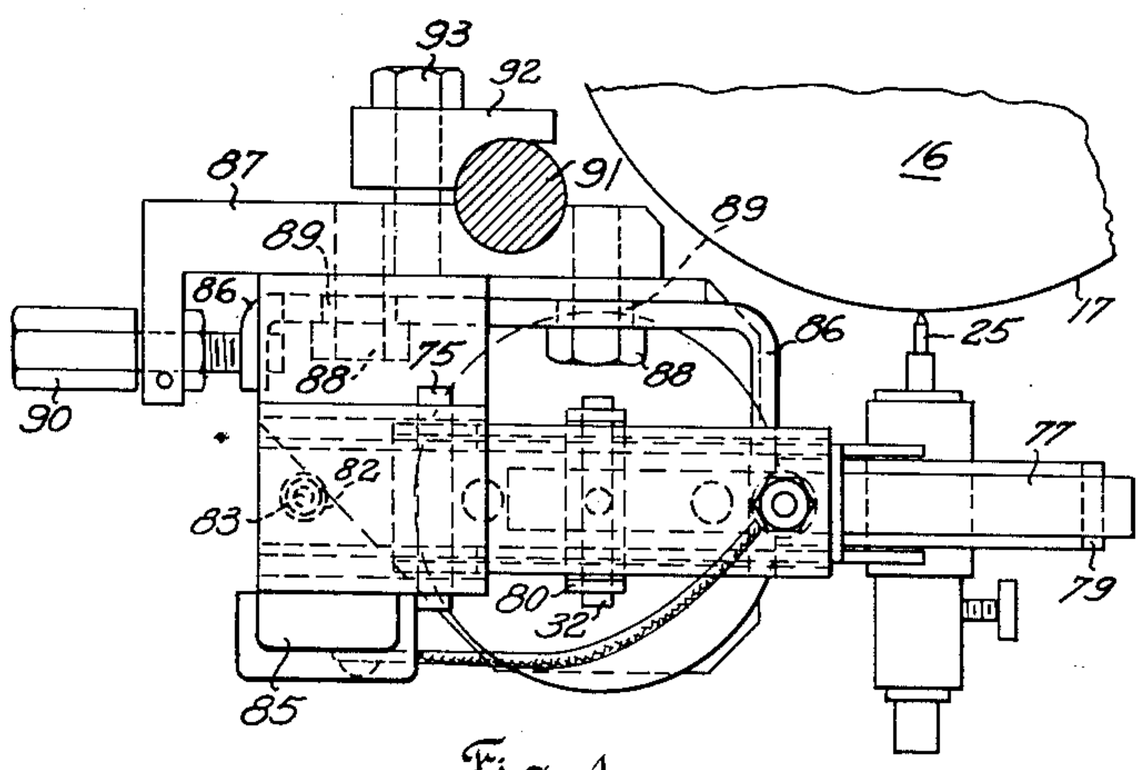

Fig. 4

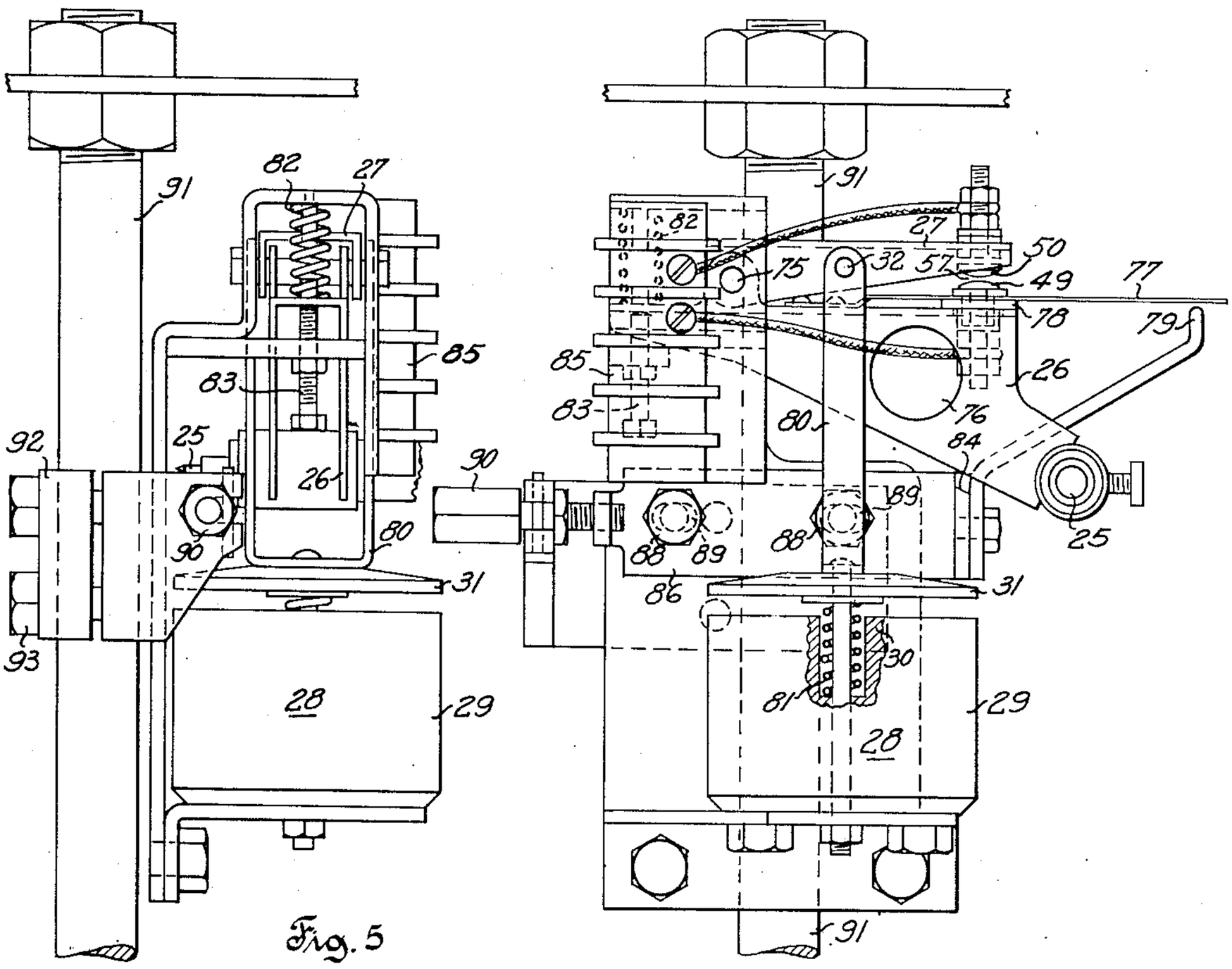

Fig. 5

Fig. 3

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SPEEDGRAPH RECORDER

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7 Claims. (Cl. 346—23)

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This invention relates to recording devices and more particularly to the speedgraph type of recorder.

The term speedgraph recorder or speedgraph is generally applied to any apparatus for recording a travel vs. time graph of a movable element. The present invention is particularly related to but not limited to a speedgraph for recording the timing and the sequence of the various actions occurring in commercial circuit breakers.

Speedgraphs used for analyzing the operation of circuit breakers comprise two vital parts, i. e. a motor driven rotating drum carrying a ruled chart and a stylus carrier operated by the lift rod of the circuit breaker. The rotary motion of the drum gives the time as the abscissa on the chart and the ordinate of the chart represents the travel of the circuit breaker lift rod. The time reference mark which enables evaluation of the travel time characteristics of the circuit breaker is that point at which energization of the breaker's trip coil takes place. Serious difficulties were encountered heretofore, in synchronizing with a high degree of accuracy the electric trip coil energizing impulse and the mechanical impulse by which the stylus was caused to trace the time reference mark. These difficulties were overcome in the new and improved speedgraph set forth and claimed herein.

This is accomplished by providing a timing stylus adapted to move along the surface of the chart, and a switch the closing of which energizes the trip coil of the circuit breaker. Complete synchronism of stylus action and trip coil energization is achieved by providing a new and improved means for operating both the stylus and the switch. This means substantially simultaneously moves the timing stylus a short distance and closes the trip initiating switch, thus precluding any delay between the actuation of the stylus and trip circuit initiation. The mark made by the timing stylus permits a good identification of the crucial point of time, thus permitting accurate evaluation of the travel vs. time characteristic. This initial mark of the timing stylus is substantially perpendicular to the direction of graph sheet advancement.

It is, therefore, one object of the present invention to provide a new and improved recording device.

Another object of this invention is to provide a new and improved speedgraph in which operation of a timing device and initiation of the movement of a movable element are effected substantially simultaneously.

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A further object of this invention is to provide a new and improved speedgraph in which a marker is actuated during advancement of a graph sheet so as to provide a mark on the graph sheet substantially perpendicular to the direction of graph sheet advancement.

A still further object of this invention is to provide a new and improved speedgraph in which a graph sheet moves at a predetermined rate of advancement and a timing stylus is actuated initially at a predetermined velocity so as to provide a mark substantially perpendicular to the direction of graph sheet advancement.

Objects and advantages other than those set forth will be apparent from the following description when read in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic showing of a speedgraph in operative relationship to a circuit breaker;

Fig. 2 is a graph of the timing and sequence of the various actions occurring in commercial circuit breakers and a comparison of various types of timing indications;

Fig. 3 is a front view showing the structural detail of the timing stylus operating means illustrated in Fig. 1;

Fig. 4 is a top view of the timing stylus operating means illustrated in Fig. 3; and

Fig. 5 is an end view of the timing stylus operating means illustrated in Fig. 3.

Referring more particularly to the drawing by characters of reference, Fig. 1 illustrates a recording device or speedgraph 8 in operative relationship to a movable element 9. Element 9 is represented schematically as a circuit breaker but is merely an example of one form of device capable of being studied with this invention.

Circuit breaker 9 may be of any known design used in power transmission and control circuits and, as is well known to those skilled in the art, may include a system of linkages, springs, cams, solenoids, contacts, arc control devices and auxiliary equipment mounted upon a massive frame. Only so much of the circuit breaker and its operation as is necessary for a clear understanding of the speedgraph and its mode of operation, is explained and diagrammatically illustrated herein. To this end, there is indicated at 10 of Fig. 1 a pair of movable contacts of the circuit breaker 9, which when closed engage stationary contacts 11.

The movable contacts 10 are carried by a vertically reciprocating member or lift rod 12. In describing this invention, it is unnecessary to

explain in detail the arrangement used in engaging and disengaging the arcing contacts since its operation and construction are well known to those skilled in the art and to whom the present specification is directed. It will be assumed that the opening and closing movements of the arcing contacts 10 and 11 are controlled by the typical arrangement of a trip solenoid 13 and a closing solenoid 14.

The recording device or speedgraph of this invention is adapted to produce a record in the form of a curve showing graphically the opening and closing strokes of the movable contacts of the circuit breaker 9. The character of the curve, upon analysis indicates the functioning of circuit breaker constituents which are involved in the opening and closing movements of the contacts 10 and 11. It is therefore necessary to have a connection between the travel device and some part of the circuit breaker that moves with, or moves correspondingly to, the movable contacts 10. Usually there is attached to reciprocating member 12, which is commonly referred to as a lift rod, a test rod or element 15 which is detachably fixed to member 12 so that it may move correspondingly with member 12.

The speedgraph 8 comprises a drum 16 carrying a vertically and horizontally ruled chart or graph sheet 17. Drum 16 and graph sheet 17 are rotatable at a definite known speed in any suitable manner, such as by means of a synchronous electric motor 18 and suitable gears 19 and 23. Motor 18 is energized by a suitable source of alternating current represented in Fig. 1 by an alternator 20 through circuit 21. Switch 22 controls the energization of circuit 21.

The graph sheet is contacted by a marker which, for example, may be a pencil stylus 24 which is appropriately mounted upon test rod 15 and held in yielding contact upon the graph sheet by a spring (not shown) or any other suitable means. The stylus 24 commonly known as a traveling stylus is elevated and lowered by the reciprocating movements of the test rod 15, as the drum 16 and graph sheet 17 are rotated relative to the pencil at a known constant speed. With the drum rotating and the stylus moving vertically the stylus 24 will apply a line on the graph sheet in a direction transverse of the direction of graph sheet advancement. The speed of the drum is so coordinated with the markings on the graph sheet that the drum rotation gives time in cycles or seconds as the abscissas on the graph, while the ordinates of the graph represent the travel of the circuit breaker contact mechanism.

In accordance with this invention a second marker or stylus 25 called a timing stylus is provided to indicate on graph sheet 17 a time reference mark which enables evaluation of the travel time characteristic of stylus 24. Stylus 25 is mounted on a pivotally mounted lever 26 and is held in yielding contact upon graph sheet 17. Stylus 25 is adapted to move across graph sheet 17 upon movement of lever 26 under the action of a pivotally mounted lever 27. Lever 27, in turn, is actuated by a relay means 28 comprising a coil 29, iron core 30 (illustrated in Fig. 3) and armature 31, one end of which is secured to lever 27 at a point 32 between the ends thereof.

A relay means 35 controls the energization of relay means 28. Relay means 35 comprises a coil 37, an armature 39, and contacts 40 and 41. Contacts 40 are connected in series with coil 37 of relay means 35 across the source of alternating current supply 20 by means of a circuit 36 and switch 22.

Contacts 41 are connected in series with coil 29 of relay means 28 across a suitable direct current source of supply 47 by means of a circuit 48.

For timing a tripping operation of circuit breaker 9, levers 26 and 27, supporting cooperating contacts 49 and 50, respectively, form upon engagement of insulated contacts 49 and 50 a closed electric circuit 51 comprising in series relationship supply 47, contacts 49 and 50, a selector switch 52 having its movable contact actuated into a first closed position engaging a fixed contact 54, and trip coil 13 back to the direct current supply 47. For timing a closing operation of circuit breaker 9, the movable contact of switch 52 is actuated into a second closed position engaging another fixed contact 53 to remove trip coil 13 from circuit 51 and substitute therefor closing coil 14 or the coil of a relay for connecting coil 14 to a suitable source. A gap 57 of a predetermined size is provided between contacts 49 and 50 when coil 29 is not energized.

Armature 39 of relay means 35 is actuated when drum 16 is in a predetermined position to close the circuit 36 to energize coil 37 by any suitable means which, for example, may be a cam 58 actuated by motor 18 through gears 19, 59. Cam 58 cooperates with an abutment 60 mounted on armature 39.

Fig. 2 illustrates graphically the actions occurring in commercial circuit breakers and a comparison of various types of timing indications. Curve 61 is a graphical illustration of the travel of the circuit breaker movable contact 10 from the closed position marked 62 on the graph to the fully open position marked 63, to the closed position marked 64. Point 65 indicates the point of curve 61 at which the trip coil was first energized which resulted in the release of the lift rod at point 62.

Curve 66 illustrates the type of curve drawn by the stylus 25 of Fig. 1. Point 67 is that point of curve 66 at which the trip or closing coil of breaker 9 is first energized.

Curve 70 represents an ideal record which shows a timing stylus making the line 71 upon energization of a trip or closing coil.

Curve 72 illustrates the type of curve drawn by speedgraphs of the prior art wherein the point of energization of the trip or closing coil may be at any point between the positions 73 and 74.

Figs. 3, 4 and 5 illustrate structural details of the timing stylus 25 and its operating mechanism not shown in Fig. 1. Lever 26 pivoted at a point 75 supports stylus 25. A hole 76 is provided in lever 26 to reduce the weight of lever 26 as much as possible, thereby permitting faster acceleration thereof. Contact 49 is insulatingly supported by a lightweight leaf spring 77 separated from lever 26 by a washer 78 but secured thereto. Horn shaped stop 79 limits the downward movement of leaf spring 77. The gap between leaf spring 77 and stop 79 is very small. Contact 50 is insulatingly mounted on lever 27 which is hingedly supported at point 75. Link 80 connected at one end thereof to lever 27 at point 32 is rigidly secured at its other end to armature 31. Spring 81 biases armature 31, link 80, lever 27 and contact 50 in an upward or counterclockwise direction. Spring 82 biases lever 26, which is journaled at 75, in a counterclockwise direction by acting on an arm of lever 26 extending to the left of point 75. The movement of lever

26 in a counterclockwise direction is limited by an adjustment screw 83. Rotation of lever 26 against the bias of spring 82 in clockwise direction is limited by an abutment or stop 84. The terminals of the electric circuits 48 and 51 are formed at a terminal block 85 connected to contacts 49, 50 through flexible leads.

The above described timing stylus structure is supported by an angular bracket member 86 more clearly illustrated in Figs. 3 and 4. Member 86 is secured to a support 87 by means of a pair of screws 88 passing through a pair of oblong holes 89 provided in member 86. These holes are provided so that adjustments may be made to set the axis of stylus 25 and the axis of the traveling stylus 24 in a predetermined relationship such that the plane defined by the axes intersects the drum along one of its generatrices. The proper position of bracket member 86 can be fixed by an adjustment nut 90 working on a threaded stud attached to the left end of bracket 86. Support 87 is clamped to a column 91 of the speedgraph structure by means of a clamp 92 and screws 93.

Referring particularly to Fig. 1, the sequence of operation is as follows:

If a tripping cycle of the breaker is desired to be recorded by the speedgraph, selector switch 52 is moved to close contact 54, thus permitting trip coil 13 to be energized upon closing of contacts 49 and 50. Control switch 22 is then closed, and the motor 18 starts, rotating the drum 16 and cam 58. Cam 58 was initially placed in a position permitting it to travel a predetermined distance before engaging abutment 60 mounted on armature 39. This predetermined travel, which may correspond to a number of revolutions of drum 16 depending upon the ratio of gears 23, 59, eliminates errors due to play in the gears and starting time of the motor. When cam 58 engages abutment 60, drum 16 has reached the proper speed for taking a recording of an opening operation of the breaker. Actuation of abutment 60 by cam 58 causes closure of contacts 40, 41, thus completing circuit 36 for sealing in relay 35 and circuit 48 for energizing relay 28. Energization of relay 28 causes clockwise actuation of lever 27 and engagement of contacts 49 and 50 which control and energize trip coil 13.

The circuit breaker then trips, usually by release of a latch, as is well known in the art. The movement of the lift rod is traced on the graph sheet.

Substantially simultaneously with the closing or engagement of contacts 49 and 50 lever 26 is actuated by lever 27 in a clockwise direction and stylus 25 secured thereto draws a mark or curve on graph sheet 17 indicating the exact time at which the trip coil was energized. This mark enables evaluation of the travel time characteristic drawn by stylus 24 which is directly connected to the lift rod of the circuit breaker.

In order to accurately evaluate the travel time, characteristic of the circuit breaker a common means such as a rapidly acting electromagnetic solenoid relay 28 is used to operate both the stylus 25 and the switch for energizing the trip coil 13, namely contacts 49 and 50. Relay 28 moves the timing stylus 25 a short distance substantially in the direction of a generatrix of drum 16 and also closes contacts 49 and 50, thus precluding even the slightest time interval between the movement of stylus 25 and the trip circuit initiation.

In prior art speedgraphs, the mark made by the timing stylus is a slanting line as illustrated by curve 72 in Fig. 2. This type of curve permits

but a poor identification of the crucial point of time at which trip or closing coil energization occurs. The trip or closing coil could have been energized at any point between points 73 and 74 on curve 72. Thus, an accurate evaluation of the travel vs. time characteristic was impossible. The slanting character of that mark is due to the fact that it is the result of a motion having no substantial component in the direction of the drum circumference, and only directed in the direction of a generatrix of the drum.

The ideal timing mark would be that as illustrated in curve 70 of Fig. 2 wherein the marker or stylus having a component of motion in the direction of the drum circumference is equal at all times to the drum motion in the direction of graph sheet advancement. Thus the stylus would provide a mark as illustrated by line 71 of curve 70.

As disclosed and claimed in this invention the structure set forth draws a mark or curve 66 as illustrated in Fig. 2 which is practically as good as the ideal record illustrated by curve 70. By judiciously selecting the pivot point 75 of lever 26 and the distance between point 75 and the stylus 25 in such a way that the initial circumferential velocity component of stylus 25 is substantially equal to the circumferential velocity of the drum, a curve 66 is drawn which is tangent at point 67 to a generatrix of the drum.

To obtain a curve such as curve 66 by a timing stylus, the stylus must be moved initially at a high speed and with an initial velocity component of motion in the direction of the movement of the drum substantially equal to the circumferential velocity of the drum. The high initial velocity component of the motion of stylus 25 in the direction of movement of drum 16 is achieved by permitting the stylus operator or lever 27 to be accelerated to a high velocity before it is allowed to act upon stylus 25. This principle is applied as follows in this particular embodiment.

Stylus 25 and lever 26 are actuated by the impact of contact 50 upon contact 49, the latter transmitting the impulse received from contact 50 to lever 26. Contact 50 is, in turn, actuated by relay 28 and more particularly armature 31, link 80, and lever 27. The gap 57 normally present between contacts 49 and 50 constitutes a lost motion connection which causes the delay of record or curve 66 until lever 27 has reached a predetermined high velocity.

Another important feature inherent in this invention is the elimination of bouncing of contacts 49 and 50 upon engagement thereof. At the time when contacts 49 and 50 engage each other the velocity of and the kinetic energy inherent in the moving system 31, 80, 27 and 50 is high, thus, the tendency of contact 50 is to bounce back from cooperating contact 49. Contact 49 which is arranged between contact 50 and lever 26 transmits the impulse of the former to the latter. This results in a rapid acceleration of lever 26 which stops when it engages abutment 84. Shortly after the actuation of lever 26, leaf spring 77 is engaged by abutment 79. Contacts 49 and 50, however, remain in engagement while the moving system 31, 80, 27 and 50 continues its motion against the relatively weak action of leaf spring 77.

It is evident from the structures illustrated in Figs. 1, 3–5 that the time constant of coil 29 need not be considered in evaluating the curves of Fig. 2 drawn by this improved speedgraph since it does not affect the drawing of the curves in any way.

This is a definite advantage over the prior art arrangements which required consideration of solenoid time constant in evaluating their travel time records.

The graph sheet 17 is mounted on drum 16 in any suitable manner. For example graph sheet 17 may be applied to the drum in an endless band formation and held to the drum by means of a pair of garter springs (not shown). A vertical groove may be provided along the length of the drum, whereby the graph sheet may be cut along the straight line of the groove so as to remove it from the drum. In prior art arrangements a pin was usually provided on the drum to preclude slippage of the band-like chart about the drum and also to provide a means by which the graph sheet may be arranged in a prescribed position upon the recording drum, thus causing initiation of the circuit breaker contact movement at a prescribed position of the marker relative to the recording drum. The object of this prior art system was to synchronize initiation of the movement of the breaker contacts and registration of the stylus with a predetermined point on the graph sheet, thus obtaining a time reference on the graph sheet.

In accordance with the invention claimed the graph sheet may be placed in a random fashion on the drum so that the circuit breaker contact movements are initiated at a random position of the travel stylus 24 upon the graph sheet. The timing stylus 25 provides the time reference mark or curve. The fact that the traveling stylus 24 registers on the graph sheet at the time of initiation of the movement of the circuit breaker contacts on a prescribed position of the recording drum has nothing whatsoever to do with obtaining a time reference. The traveling stylus 24 is caused to register at the time of initiation of the movement of the breaker contacts with a prescribed generatrix of the recording drum simply because it is desirable to have the drum make a prescribed number of revolutions before recording is started.

It is obvious to one skilled in the art that a plurality of auxiliary styli may be mounted on the speedgraph to record on the graph sheet other important time reference marks in addition to that indicated by the main timing stylus 25 without departing from the spirit or scope of this invention. For example an auxiliary stylus may be used to record the point of time when the circuit of the closing coil is closed or the point of time when recoupling of a mechanically trip free circuit breaker release mechanism takes place.

Although only the tripping cycle of circuit breaker operation was fully described it is readily understood that a closing operation of the circuit breaker may be similarly recorded by simply moving selector switch 52 to position closing contact 53. Both the tripping and closing operations may be obtained on the same chart and without stopping motor 18 as shown if so desired.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. An apparatus for recording the movements of circuit breaker contacts, comprising: a recording drum, a graph sheet mounted on said drum, means for rotating said drum to provide a predetermined rate of advancement of said graph sheet, a first marker operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating the movement of the circuit breaker contacts to said first marker as the graph sheet advances, a second marker operative upon said graph sheet, and means under the control of the graph sheet advancing means for initiating the circuit breaker contact movement and substantially concurrently therewith the movement of said second marker across said graph sheet in a direction transverse of the direction of graph sheet advancement.

2. An apparatus for recording the movements of circuit breaker contacts, comprising: a recording drum, a graph sheet mounted on said drum, means for rotating said drum to provide a predetermined rate of advancement of said graph sheet, a first marker operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating the movement of the circuit breaker contacts to said first marker as the graph sheet advances, a second marker operative upon said graph sheet, and means under the control of the graph sheet advancing means for initiating the circuit breaker contact movement and substantially concurrently therewith the movement of said second marker across said graph sheet, said second marker initially moving across said graph sheet in a direction substantially parallel with a generatrix of said drum.

3. An apparatus for recording the movement of circuit breaker contacts, comprising: a recording drum, a graph sheet mounted on said drum, means for rotating said drum at a given circumferential velocity so as to provide a predetermined rate of advancement of said graph sheet, a first stylus operative upon said graph sheet in a direction transversely of the direction of graph sheet advancement, means for translating the movement of the circuit breaker contacts to said first stylus as the graph sheet advances, a second stylus operative upon said graph sheet, and a quick acting electromagnetic relay under the control of the graph sheet advancing means for initiating the circuit breaker contact movement and substantially concurrently therewith the movement of said second stylus across said graph sheet, said second stylus having an initial velocity component in the circumferential direction of said drum substantially equal to the circumferential velocity of said drum so as to provide a mark on said graph sheet substantially parallel with a generatrix of said drum.

4. An apparatus for recording relative movements comprising: means for moving a graph sheet at a predetermined rate of advancement, a first marker operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating a given movement to said first marker as the graph sheet advances, a pivotally mounted lever, a second marker secured to said lever and operative upon said graph sheet, and means under the control of the graph sheet advancing means for initiating said given movement and substantially concurrently therewith the movement of said lever to move said second marker to provide a mark on said graph sheet substantially perpendicular to the direction of graph sheet advancement.

5. An apparatus for recording the movement

of circuit breaker contacts comprising: means for moving a graph sheet at a predetermined rate of advancement, a first marker operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating the movement of the circuit breaker contacts to said first marker as the graph sheet advances, a pivotally mounted lever, a second marker secured to said lever and operative upon said graph sheet for providing a predetermined composite movement of said second marker across said graph sheet, said composite movement comprising a component in the direction of graph sheet advancement and a component perpendicular to the direction of graph sheet advancement, a second pivotally mounted lever, means defining a lost motion connection between said levers for actuating said first lever, and means for actuating said second lever to a predetermined velocity before said second lever actuates said first lever so as to provide a movement of said marker that provides an initial mark on said graph sheet substantially perpendicular to the direction of graph sheet advancement.

6. In combination: a tripping solenoid comprising a coil and an armature, a closing solenoid comprising a coil and an armature, a circuit breaker comprising a movable arcing contact, a cooperating stationary arcing contact, and a rod for actuating said movable contact, said tripping solenoid armature releasing said movable contact upon energization of said tripping solenoid and said closing solenoid armature actuating said movable rod upon energization of said closing solenoid to cause engagement of said contacts, switch means manually operable to control selective energization of said tripping solenoid and said closing solenoid, a cam driven at a constant speed, a cam operated contact, relay means controlled by said cam operated contact, a pair of contacts controlled by said relay means for energizing a selected one of said solenoids following manual closing of said switch means, a recording drum, a graph sheet mounted on said drum, means for rotating said drum at a speed in a predetermined relation to the speed of said cam, a first stylus operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating the movement of said movable contact of said circuit breaker to said first stylus, a second stylus operative upon said graph sheet, and means connected to one of said pair of contacts for actuating said second stylus upon engagement of said pair of contacts, whereby said second stylus records on said graph sheet substantially the time of energization of one of said solenoids which controls the actuation of said movable contact of the circuit breaker, said second stylus initially moving across said graph sheet in a direction substantially parallel with a generatrix of said drum.

7. In combination: a tripping solenoid comprising a coil and an armature, a closing solenoid comprising a coil and an armature, a circuit breaker comprising a movable arcing contact, a cooperating stationary arcing contact, and a rod for actuating said movable contact, said tripping solenoid armature releasing said movable contact upon energization of said tripping solenoid and said closing solenoid armature actuating said movable rod upon energization of said closing solenoid to cause engagement of said contacts, switch means manually operable to control selective energization of said tripping solenoid and said closing solenoid, a cam driven at a constant speed, two cam operated contacts closing substantially concurrently, a relay means energized upon closing of one of said cam operated contacts for retaining said cam operated contacts in closed circuit position, a second relay means controlled by the other said cam operated contact, a pair of contacts controlled by said second relay means for energizing a selected one of said solenoids following manual closing of said switch means, a recording drum, a graph sheet mounted on said drum, means for rotating said drum at a speed in a predetermined relation to the speed of said cam, a first stylus operative upon said graph sheet in a direction transverse of the direction of graph sheet advancement, means for translating the movement of said movable contact of said circuit breaker to said first stylus, a second stylus operative upon said graph sheet, and means connected to one of said pairs of contacts for actuating said second stylus upon engagement of said pair of contacts, whereby said second stylus records on said graph sheet substantially the time of energization of one of said solenoids which controls the actuation of said movable contact of the circuit breaker, said second stylus initially moving across said graph sheet in a direction substantially parallel with a generatrix of said drum.

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